NEURON® CHIP RS-485 Transceiver

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Introduction

This application note describes the implementation of an RS-485 transceiver for use with the NEURON CHIP in a LONWORKS network.

The intent is to provide the user with a solution and to answer pertinent questions relating to the NEURON CHIP's interface characteristics as they relate to the RS-485 standard. For more information on the RS-485 standard, refer to the EIA RS-485 document published by the Electronic Industries Association [1].

The RS-485 standard provides a platform for multi-point data transmission over a balanced twisted-pair transmission line.

The differential interconnection scheme specified by the standard allows for a reasonable amount of immunity to common mode noise without requiring large voltage swings on the transmission medium that are common to single-ended interconnection standards such as RS-232C.

In addition, the maximum line length and baud rate allowed by the RS-485 standard are a dramatic improvement over those of the older standards such as RS-232C and RS-423A.

Most of the improvements mentioned above are not only due to the differential drive of the transmission lines, but are also a result of tighter specification of the driver, receiver and line characteristics. A comparison of some of these characteristics among different EIA standards is shown in table 1.

Parameter	RS-232C	RS-423A	RS-422A	RS-485
Mode	Single-ended	Single-ended	Differential	Differential
Number of drivers and receivers (max)	1 Driver 1 Receiver	1 Driver 10 Receivers	1 Driver 10 Receivers	32 Unit Loads (see text)
Baud rate (max)	20 KBaud	100 KBaud	10 MBaud	10 MBaud
Line length (max)	50 ft/15 m	4000 ft/1200 m	4000 ft/1200 m	4000 ft/1200 m
Common mode voltage (max)	±25 V	±6 V	-0.25 to 6 V	-7 to 12 V
Driver differential output	± 5 V min	± 3.6 V min	±2 V min	±1.5 V min
Driver load	3 KΩ to 7 KΩ	450 Ω min	100 Ω min	60 Ω min
Receiver sensitivity	±3 V	±200 mV	±200 mV	±200 mV
Receiver input resistance	3 KΩ to 7 KΩ	4 KΩ	4 KΩ	12 KΩ

Table 1. A comparison of some popular EIA line circuit standards

As shown in table 1, the RS-485 standard allows multiple drivers and receivers to be connected to the same line, thus facilitating multi-drop networks with each node on the network capable of receiving and generating data.

It is important to note that the EIA specification for the maximum number of transceivers (driver/receiver combinations) is defined in terms of the UNIT LOAD. A unit load is defined as a load that allows 1mA of current under the worst network conditions (12 v common mode). Given this definition, the RS-485 standard specifies a maximum of 32 unit loads on a bus at any given time. The loads may consist of drivers and receivers.

It is possible to attach more than 32 loads to an RS-485 bus if the sum of equivalent loads does not exceed 32. For example, if each load in a network is 0.5 unit loads, then 64 loads could coexist on the line without violating the RS-485 specification.

The common mode voltage allowance specified by the RS-485 standard, as shown in table 1, allows for a good deal of ground offset voltage to exist between the nodes in a network, while the 400 mv hysteresis at the receiver inputs avoids the use of large (and slow) voltage swings typically found in a single-ended line circuit.

In the RS-485 standard, the stub (or feeder line) length is effectively defined to be zero. In multi-point communication the transmission line can be routed directly to each node in order to prevent excessive loading of the transmission line by the stubs.

Termination resistance, although not specifically defined by the standard, is generally provided by a 120Ω resistor between the differential wires at each far end of the line.

An additional attribute of the RS-485 standard is that any driver must be able to withstand the stress caused by bus contention or output shorts to ground. The maximum short circuit current of any driver must not exceed 250mA.

The maximum line length allowed for a particular RS-485 bus is a function of the baud rate of the network. The maximum baud rate specified by the RS-485 standard is 10 Mbps. The maximum line length, as shown in table 1, is 4000 feet/1200 meters. This value generally decreases as the line baud rate is increased. The rate of fall is primarily a function of the driver and receiver circuitry and is therefore specified by the manufacturer of the transceiver.

NEURON CHIP Interface

The NEURON CHIP communications port (CP.0 to CP.4) allows the user to design a custom transceiver for communication over a LONWORKS network.

The three modes supported by the NEURON CHIP are 1) direct single-ended, 2) direct differential, and 3) special-purpose. An RS-485 transceiver uses the direct single-ended mode. In this mode, the NEURON CHIP communication port pins are as follows:

Neuron Pin	Function
CP.0	RX (in)
CP.1	TX (out)
CP.2	TXenable (out)
CP.3	On/Off Sleep (out)
CP.4	Collision Detect (in)

The LONBUILDER™ Developer's Workbench allows selection of the communications port operating mode and data rate. Based on the selection, the LONBUILDER software provides the proper communications parameters to the NEURON CHIP Emulator connected to the prototype RS-485 transceiver.

In the LONBUILDER software releases 1.00 and 1.01, the user selects the direct single-ended mode of the NEURON CHIP communications port indirectly by setting the channel medium to radio frequency (RF). This selection also automatically sets the data rate at 4.883 Kbps.

Release 1.1 supports explicit selection of the direct single-ended mode as one of the custom transceiver options. It also allows selection among nine standard data rates between 4.883 Kbps and 1.25 Mbps.

Hardware

The simplest and least expensive way of designing an RS-485 transceiver is to use an off-the-shelf IC. Some of the available ICs are the following:

- SN75176 from Motorola and TI
- LTC485 from Linear Technology
- DS96176 from National Semiconductor

All three are single-chip, 8-pin DIP transceivers (one driver and one receiver) and are designed to meet or exceed the EIA RS-485 specifications.

In the design below, the LTC485 is used since its CMOS design offers a significant power reduction over its bipolar counterparts (Icc=300µA).

The LTC485 contains a driver and a receiver each having its own separate Enable pin. Figure 1 shows the connection of the NEURON CHIP to the LTC485.

The LTC485 transceiver represents an effective load of one unit load. Therefore, up to 32 transceivers may be used in a given network. As an alternative, the SN75176 transceiver represents 0.7 unit loads which would allow up to 45 nodes on a network.

Refer to Linear Technology's data sheet[2] on the LTC485 for more specific information on the IC's characteristics and behavior under various conditions.

Due to variability of design techniques, it is a good idea to pay careful attention to each manufacturer's specific data sheet.

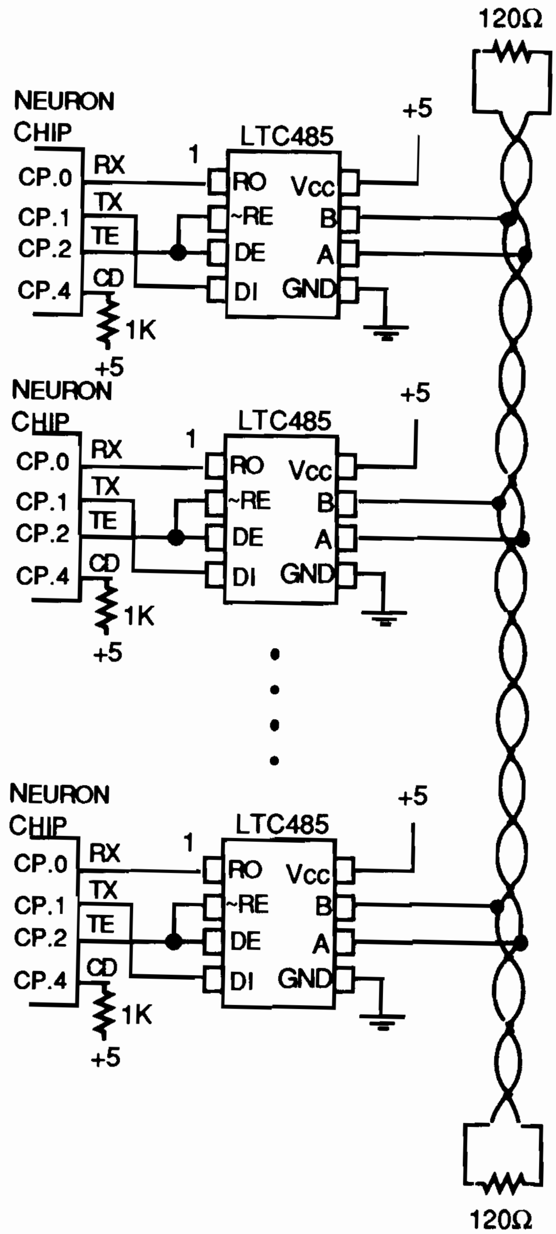

Figure 1. Interfacing the LTC485 with a NEURON CHIP

Performance

The relationship between maximum line length and baud rate for the LTC485 is shown in figure 2. The maximum line length is shown as 4000 feet/1200 meters. This value holds for baud rates up to about 100 Kbaud. Increasing the baud rate beyond that point will reduce the maximum allowed line length according to the characteristic curve shown in figure 2.

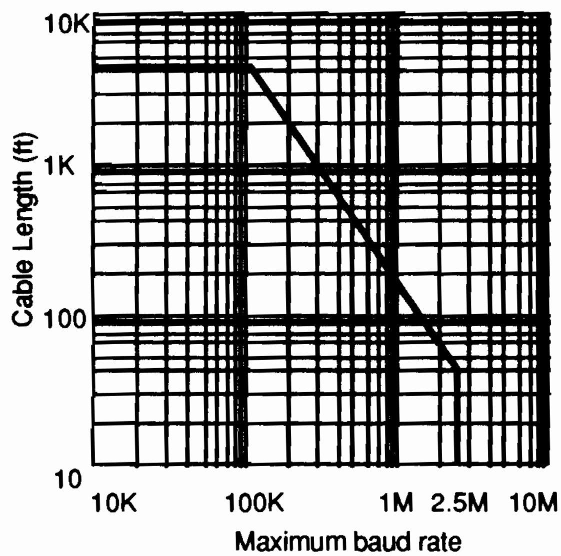

Figure 2. Approximate Maximum Cable Length vs. Baud Rate (3/2 of bit rate) for the LTC485

The NEURON CHIP makes use of Manchester encoding in the direct single-ended mode. A zero is indicated by the presence of a second transition halfway between clock transitions. This guarantees a transition in every bit period in order to assist the synchronization of the receiver clock. An important advantage of the differential Manchester encoding scheme is that it is polarity-insensitive. Any change in the transmission medium's polarity (intentional or not) has no effect on communication.

The extra transition required during the transmission of a zero effectively makes the baud rate twice as high as the bit rate during that period. This must be taken into account when calculating overall network line length. Assuming a uniform distribution of zeros and ones during transmissions, the baud rate is 1 1/2 times the actual transmission bit rate.

The table below shows some approximate values for typical line lengths given our differential Manchester encoding system. The baud rates shown are scaled to properly represent the transmission bit rates offered by the LONTALK™ protocol.

Bit Rate	Average Baud Rate	Line Length
78 Kbps	117 Kbaud	4000 ft/1200 meters
156 Kbps	234 Kbaud	1500 ft/450 meters
312 Kbps	468 Kbaud	500 ft/150 meters
625 Kbps	936 Kbaud	150 ft/45 meters
1.25 Mbps	1.875 Mbaud	60 ft/18 meters

References

1) EIA Standard RS-485; Published by Electronic Industries Association, Engineering Department, 2001 Eye Street, N.W., Washington, D.C. 20006

2) LTC485 Data sheet; Linear Technology Corporation, 1630 McCarthy Blvd., Milpitas CA 95035; (408)432-1900

3) Linear and Interface Circuits Applications, 1985, Volume 2; Texas Instruments Corporation.

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